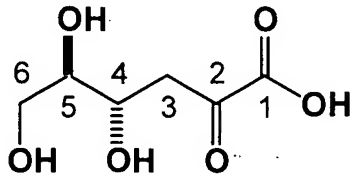
Claims

1. A method for producing 2'-deoxynucleosides or 2'-deoxynucleoside precursors from a compound of formula (I) or its salts



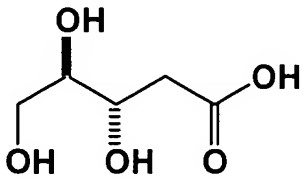
(I)

or a protected form thereof in a process comprising a decarboxylation step.

2. The method of claim 1 wherein the decarboxylation step cleaves the C1-C2 bond of the compound of formula (I) or its salts or a protected form thereof.

3. The method of claim 1 or 2, wherein the decarboxylation step is directly carried out on the compound of formula (I) or its salts or a protected form thereof.

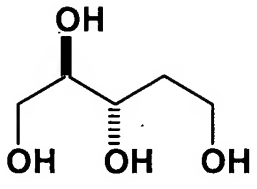
4. The method of any of claims 1 to 3, wherein the decarboxylation step takes place by reacting the compound of formula (I) or its salts or a protected form thereof with hydrogen peroxide to yield a compound of formula (II) or its salts



(II)

or a protected form thereof as a 2'-deoxynucleoside precursor.

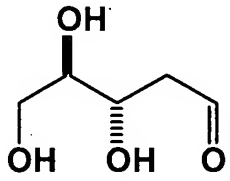
5. The method of claim 4, further comprising the conversion of the compound of formula (II) or its salts or a protected form thereof into a compound of formula (IV)



(IV)

or a protected form thereof as a 2'-deoxynucleoside precursor.

6. The method of claim 4, further comprising the conversion of the compound of formula (II) or its salts or a protected form thereof into a compound of formula (III)

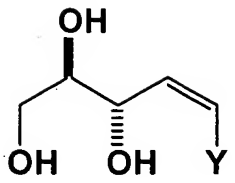


(III)

or a protected form thereof as a 2'-deoxynucleoside precursor.

7. The method of claim 6, comprising the conversion of the compound of formula (II) or its salts or a protected form thereof into the compound of formula (IV) or a protected form thereof as an intermediate which is then converted to the compound of formula (III) or a protected form thereof.

8. The method of any of claims 1 to 3, wherein the decarboxylation step takes place by reacting the compound of formula (I) or its salts or a protected form thereof with an amine Y-H, wherein H represents a hydrogen atom bound to the nitrogen atom of the amino group, to produce a compound of formula (V),



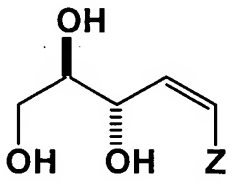
(V)

or its respective trans isomer or a protected form thereof, as a 2'-deoxynucleoside precursor.

9. The method of claim 8, wherein Y-H represents a linear or cyclic secondary amine.

10. The method of claims 8 or 9, wherein Y-H is morpholine, pyrrolidine, piperidine, N-methyl piperazine or diethylamine.

11. The method of any of claims 8 to 10, further comprising the step of reacting a compound of formula (V) or its trans isomer or a protected form thereof with Z-H, wherein H represents a hydrogen atom and Z represents a leaving group, to produce a compound of formula (VI)

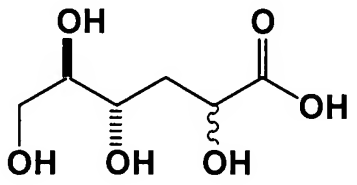


(VI)

or its respective trans isomer or a protected form thereof, as a 2'-deoxynucleoside precursor.

12. The method of claim 11, wherein Z-H is water, to produce a compound of formula (III) or a protected form thereof as a 2'-deoxynucleoside precursor.

13. The method of claim 1 or 2, wherein the compound of formula (I) or its salts or a protected form thereof is converted to a compound of formula (VII), or its salts or a protected form thereof or a mixture of the respective epimers,



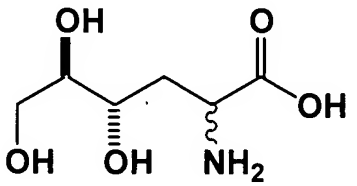
(VII)

which is then decarboxylated to yield a compound of formula (III) or a protected form thereof as a 2'-deoxynucleoside precursor.

14. The method of claim 13, wherein the conversion of (I) or its salts or a protected form thereof to (VII) or a protected form thereof takes place by reduction with sodium borohydride or by hydrogenation using Nickel Raney or Platinum oxide catalyst.

15. The method of claim 13 to 14, wherein the decarboxylation step takes place by reaction with hydrogen peroxide.

16. The method of claim 1 or 2, wherein the compound of formula (I) or its salts or a protected form thereof is converted to a compound of formula (VIII), or its salts or a protected form thereof or a mixture of the respective epimers,



(VIII)

which is then decarboxylated to yield a compound of formula (III) or a protected form thereof as a 2'-deoxynucleoside precursor.

17. The method of claim 16, wherein a compound of formula (VIII) or a protected form thereof or a mixture of the respective epimers is reacted with ninhydrin, thereby leading to the compound (III) or a protected form thereof.

18. The method of claim 16 or 17, wherein the conversion of (I) or its salts or a protected form thereof to (VIII) or a protected form thereof takes place by reductive amination with ammonia and sodium cyanoborohydride.

19. The method of any of claims 1 to 18, wherein the protective group(s) are independently chosen from acetate ester, benzoate ester, allyl ether, benzyl ether, trityl ether, ter-butyldimethylsilyl (TBDMS) ether, isopropylidene or a benzylidene acetal.

20. The method of any one of claims 1 to 3, wherein the decarboxylation step is effected by an enzymatic reaction comprising a single step.

21. The method of claim 20, wherein the enzymatic reaction is catalysed by an enzyme having keto acid decarboxylase activity.

22. The method of claim 21, wherein the enzyme having keto acid decarboxylase activity is a thiamine pyrophosphate (TPP) dependent keto acid decarboxylase.

23. The method of claim 22, wherein the TPP dependent keto acid decarboxylase is a pyruvate decarboxylase (EC 4.1.1.1), a benzoylformate decarboxylase (EC 4.1.1.7), an indolepyruvate decarboxylase (EC 4.1.1.74), a phosphonopyruvate decarboxylase, a sulfopyruvate decarboxylase (EC 4.1.1.79), an oxalyl-coenzyme A decarboxylase (EC 4.1.1.8), an oxoglutarate decarboxylase (EC 4.1.1.71) or a phenylpyruvate decarboxylase (EC 4.1.1.43).

24. The method of claim 23, wherein the pyruvate decarboxylase is of eukaryotic origin.

25. The method of claim 24, wherein the eukaryotic organism is a yeast organism.

26. The method of claim 25, wherein the yeast is Saccharomyces cerevisiae.

27. The method of claim 23, wherein the pyruvate decarboxylase is of prokaryotic origin.

28. The method of claim 27, wherein the prokaryotic organism is of the genus Zymomonas, Zymobacter or Acetobacter.

29. The method of claim 28, wherein the organism is of the species Zymomonas mobilis, Zymobacter plamae or Acetobacter pasteurianus.

30. The method of claim 23, wherein the benzoylformate decarboxylase is of prokaryotic origin.

31. The method of claim 30, wherein the prokaryotic organism is of the genus Pseudomonas.

32. The method of claim 31, wherein the organism is of the species Pseudomonas putida.

33. The method of any one of the claims 20 to 32, wherein the pH is regulated by addition of an acid between pH 5 and pH 9.

34. The method of claim 33, wherein the pH value is regulated between pH 6 and pH 8.

35. The method of claim 33 or 34, wherein the acid is HCl, H_2SO_4, D-gluconic acid or 2-dehydro-3-deoxy-D-gluconic acid.

36. The method of any one of claims 1 to 35, comprising the preliminary step of producing the compound of formula (I) from D-gluconate or a D-gluconate salt by the use of a gluconate dehydratase activity.

37. The method of claim 36, wherein the D-gluconate salt is potassium or sodium D-gluconate.

38. The method of claims 36 or 37, wherein the gluconate dehydratase is encoded by a polynucleotide comprising the nucleotide sequence selected from the group consisting of:

(a) nucleotide sequences encoding a polypeptide comprising the amino acid sequence of SEQ ID N°2;

(b) nucleotide sequences comprising the coding sequence of SEQ ID N°1;

(c) nucleotide sequences encoding a fragment encoded by a nucleotide sequence of (a) or (b);

(d) nucleotide sequences hybridising with a nucleotide sequence of any one of (a) to (c); and

(e) nucleotide sequences which deviate from the nucleoside sequence of (d) as a result of degeneracy of the genetic code.

39. The method of any one of claims 1 to 35, comprising the preliminary step of producing the compound of formula (I) from D-glucosaminate by the use of a glucosaminate deaminase activity.

40. The method of claim 39, wherein the glucosaminate deaminase is encoded by a polynucleotide comprising the nucleotide sequence selected from the group consisting of:

(a) nucleotide sequences encoding a polypeptide comprising the amino acid sequence of SEQ ID N°4;

(b) nucleotide sequences comprising the coding sequence of SEQ ID N°3;

(c) nucleotide sequences encoding a fragment encoded by a nucleotide sequence of (a) or (b);

(d) nucleotide sequences hybridising with a nucleotide sequence of any one of (a) to (c); and

(e) nucleotide sequences which deviate from the nucleoside sequence of (d) as a result of degeneracy of the genetic code.

41. An organism which is capable of enzymatically converting D-gluconate into 2-dehydro-3-deoxy-D-gluconatedue to the expression of a D-gluconate dehydratase and/or capable of enzymatically converting D-glucosaminate into 2-dehydro-3-deoxy-D-gluconatedue to the expression of a D-glucosaminate deaminase and which is capable of enzymatically converting 2-dehydro-3-deoxy-D-gluconateby decarboxylation into 2-deoxy-D-ribose due to the expression of a keto acid decarboxylase.

42. The organism of claim 41 which does not express a 2-dehydro-3-deoxy-D-gluconatekinase activity.

43. The organism of claim 41 or 42 which does not express a 2-dehydro-3-deoxy-D-gluconatealdolase activity.

44. The organism of any one of claims 41 to 43 which does not express a 2-deoxy-D-ribose aldolase activity.

45. The method of any of claims 20 to 40 which is carried out by using an organism according to any one of claims 41 to 44.

46 Use of a polynucleotide as defined in claim 38 or of a gluconate dehydratase encoded by such a polynucleotide in a method according to claims 36 or 37.

47. Use of a polynucleotide as defined in claim 40 or of a glucosaminate deaminase encoded by such a polynucleotide in a method according to claim 39.

48. Use of an enzyme having keto acid decarboxylase activity or of a polynucleotide encoding such an enzyme in a method for converting a compound of the formula (I) into 2-deoxy-D-ribose.